Chapter 6

GENERAL RISK CATEGORIES FOR WILD STEELHEAD

Many factors have contributed to the decline of wild steelhead in the Lower Columbia and Southwest Washington ESUs. NMFS (1996b) outlined the factors shown in Table 2. Cramer (1997) also reviewed factors for the decline of steelhead in the Lower Columbia River ESU. The factors NMFS described are incomplete without also including the influence of ocean conditions. A general discussion of these key factors is presented below for stocks in the LCSCI area.

Table 2. Major factors as contributing to the decline wild steelhead stock health in the Lower Columbia River and Southwest Washington ESUs; information modified from NMFS (1996b).

Lower Columbia ESU	Southwest Washington ESU
Hatchery Introgression	Hatchery Introgression
Habitat Blockages	Logging
Logging	Agriculture
Eruption of Mt. Saint Helens	Sport Harvest
Hydropower Development	Ocean Conditions
Predation	
Sport Harvest	
Ocean Conditions	

Habitat

Maintenance and restoration of habitat in support of the entire life cycle of wild steelhead is **<u>the</u>** fundamental and critical element for long term effectiveness of the LCSCI. Various recent reports have stressed the importance of habitat to salmonid restoration and recovery, and also discuss the mechanisms associated with declines in habitat quantity and quality (ISG 1996; NRC 1996; WDFW 1997a; Williams et al. 1997). The LCSCI also stresses the critical importance of habitat to wild steelhead stock health and provides a foundation for consideration and implementation of habitat protection and restoration needs and actions. Existing programs and projects that benefit wild steelhead are being identified, and a longer term habitat inventory and restoration needs assessment has begun. The focus of the LCSCI will be aimed at freshwater habitat issues and action strategies, with primary emphasis on individual subbasins. Mainstem and estuary considerations will also be addressed. Since most steelhead stocks in the LCSCI area are found below Bonneville Dam, concerns involving mainstem dam passage are much less of an issue than they are for ESUs further upstream in the Columbia River watershed. However, dams and passage issues are present within tributaries and thus remain a concern for steelhead protection and rebuilding efforts in the LCSCI.

Many governmental entities, industrial entities, landowners, and other stakeholders directly and/or indirectly affect wild salmonid habitat. Most entities have limited regulatory authority to influence habitat protection. However, use of regulatory authority must be applied, and cooperative work with other entities and stakeholders is needed to help identify habitat needs for steelhead, and to help promote development and implementation of protection and restoration strategies.

Mount St. Helens

Parts of the LCSCI area are subject to the influence of contemporary and future volcanic activity. Wild steelhead evolved under such circumstances, which contribute to their adaptive life history strategies and very resilient population dynamics. Obviously, it is not possible to manage volcanic events. However, it is possible and necessary to consider the probability and impacts of such events when evaluating risks and strategies leading to long-term conservation of steelhead in the LCSCI area.

Mount St. Helens is located at the headwaters of several lower Columbia River tributaries (e.g., the Toutle, Kalama, and Lewis rivers). The mountain erupted violently in the spring of 1980, causing widespread catastrophic conditions in affected aquatic systems due to heated and mud-laden flows into many streams, including the mainstem Columbia River below its confluence with the Cowlitz River. Entry of hatchery and wild steelhead into tributary streams was affected due to thermal and sediment barriers, and spawning and rearing habitat was substantially altered. Leider (1989) reported that many steelhead bound for the Cowlitz/Toutle basins were diverted into the Kalama River system, where many remained to spawn.

The affected basin having the most prolonged impact on wild steelhead is the North Fork of the Toutle River. There a sediment retention structure was constructed to protect against flows, risks, and problems unacceptable to communities downstream. These objectives appear to have been largely achieved; however, the structure presents a blockage to passage by anadromous salmonids. Steelhead habitat and stock status in other basins appears to have recovered fairly rapidly.

Tributary Dams/Hydropower

Dams and hydropower projects benefit society in various ways but they also significantly alter the natural river systems in which they are located (Stanford et al. 1996). In the area bounded by the Lower Columbia Steelhead Conservation Initiative (LCSCI) (Figures 1 and 2), the effects of dams and hydroelectric projects on wild steelhead are acute. Risks to wild steelhead and other anadromous fishes include habitat factors such as barriers to fish passage, reduced channel and floodplain complexity, loss of riparian and wetland integrity, reduced water quality, and altered hydrology and stream flow.

In the LCSCI area, major tributary dams exist in the Lower Columbia ESU; they are not a major factor in the Southwest Washington ESU. Therefore, this section will focus entirely on that portion of the LCSCI represented by the Lower Columbia ESU.

In the Lower Columbia ESU, the area located upstream of dams (not including the sediment retention dam in the Toutle River watershed) is about 58% of the entire available watershed area. Two major dam complexes exist, one on the Cowlitz River and one on the North Fork Lewis River. These presently block anadromous fish and have caused a number of other impacts to wild steelhead. Dam construction and operation, in many cases, have stressed aquatic systems, and the fish that reside and migrate in them, beyond their ability to adapt. Natural flow patterns and geologic conditions have created the context in which wild steelhead have evolved. Disruption of this context typically has adverse consequences for the health of wild steelhead stocks. Any dam can contribute to several factors for decline, but all factors do not result from each dam.

Dams can inhibit the natural downstream flow of water to plants and for the transport of nutrients on which fish and their prey depend, and impede the migration of fish. Access to upstream habitat by migrating fish may be either completely eliminated or restricted, unless passage through bypass reaches is good. While fish passage structures, when present, enable some fish to pass around a dam, where a series of dams exist, these populations are still jeopardized by the cumulative impact of passing multiple dams. Mortality exists at each dam; thus the migrant fish population decreases as each dam is passed. Some dams have no fish passage facilities at all. Transporting fish around dams is sometimes feasible, but can increase the risk of disease, add to stress-induced mortality, increase predation risks, and diminish homing abilities.

Some dams in the Lower Columbia ESU, including Swift #2, Merwin, Mayfield, and Mossyrock, alter timing and quantity of river flow regimes by diverting water for power or other purposes that would otherwise contribute to the health of the instream ecosystem. In the most serious cases, bypass reaches below dams can become completely de-watered. Some original federal licenses issued to existing hydropower projects in the Lower Columbia ESU did not require flows in bypass reaches, resulting in passage barriers, stranding, loss of rearing, holding and spawning habitat, and poor water quality. By withholding and then releasing water to generate power in times of peak demand or for other extractive uses, dams can cause extreme variations in instream and riparian habitat conditions downstream. Conditions alternate from low water to great surges of water, a situation which can strand fish and erode soil and vegetation. These irregular releases greatly affect natural seasonal flow variations in which fish stocks have evolved and impact fish growth and reproduction cycles. Unnatural seasonal fluctuations also often conflict with seasonal habitat needs of various aquatic organisms both upstream and downstream.

In contrast to natural streamflows, dams create reservoirs in which water velocities are greatly decreased. This unnatural state may present a confusing flow pattern that disorients migratory fish and results in them being lost or delayed once they enter the reservoirs. Wild steelhead depend on high flows to facilitate smolt outmigration each spring and to guide the return of adults to upstream spawning grounds.

Reservoirs inundate riverine habitat, resulting in a permanent loss of spawning habitat in the affected reaches, diminishing the quality of habitat for juvenile rearing, and altering macroinvertebrate communities on which steelhead depend for food. Operation of dams often leads to fluctuating water levels in reservoirs. Peaking power operations can cause dramatic changes in water levels, which degrade upstream shorelines and disturb fish and bottom dwelling organisms.

Wild steelhead require suitable water temperatures and oxygen levels. Dams can create environments that greatly alter these variables to the detriment of the stocks. Dams can decrease oxygen levels in reservoir waters and disturb the balance of other natural gases downstream. When oxygen-deprived water is released from behind a dam, it may kill fish and vegetation downstream. In addition, the spilling of water from large dams contributes to super-saturation of nitrogen in the water immediately downstream of the dam, which can also harm fish life.

Dams can inhibit the natural downstream flow of silt, debris, and nutrients in river systems. By slowing natural flows, dams allow silt to collect on river bottoms and bury steelhead spawning habitat and benthic organisms (insects). Benthic organisms provide needed food supplies for fish. Above dams silt may settle out in the slow moving water and accumulate heavy metals and other pollutants. Gravel, logs and other debris are also trapped by dams, making them unavailable for downstream food and habitat.

Hydropower dams kill and injure fish that pass through turbines, if adequate screening is absent. Fish are drawn into power turbines, where they are subject to striking turbine blades and hydraulic shear. Fish are also drawn into diversion channels unless they are properly screened.

Dams can create habitat conditions that increase predator population sizes and increase the vulnerability of salmonid prey. Warm, turbid reservoirs often favor indigenous predator species. In addition, passage through fish ladders and turbines can injure, disorient, and concentrate fish, making them easy prey for avian predators such as cormorants, gulls, herons, and eagles.

Mitigation for dams in the form of hatchery production can increase ecological, genetic, harvest, and disease risks to wild steelhead. Chemicals used in hatchery practices can be released to the stream.

Major hydroelectric projects exist on the Cowlitz and Lewis rivers that have contributed to a number of factors for decline. During upcoming Federal Energy Regulatory Commission (FERC) project relicensing processes, state and federal fish and wildlife agencies will recommend and/or require measures to mitigate the factors for decline attributable to these projects. For each group of projects, the LCSCI outlines priority recommendations/requirements associated with various factors for decline. Although dam removal is being considered as a restoration measure for wild salmonids in some areas, dam removal is not anticipated in the Lewis and Cowlitz basins, so the measures are intended as mitigation for ongoing impacts of projects. Factors of primary concern in the Lower Columbia ESU include upstream and downstream passage, inundation of stream habitat, streamflow and ramping, and gas supersaturation.

Ocean Conditions

The condition of the ocean environment plays a key role in trends in survival of Pacific salmon and steelhead. Wild steelhead stocks from the Columbia River spend up to four years rearing in the marine environment before returning to freshwater to spawn. Available information suggests they migrate in a counterclockwise pattern to the North Pacific Ocean in a dispersed fashion. This long marine rearing interval means that variations in oceanic conditions affecting productivity and occurrence of predators play a key role in overall health of wild steelhead stocks and their stock status trends over time. Climatic changes can impact numerous physical, biological, and chemical processes in the ocean that directly or indirectly influence fish population dynamics (Lawson 1993). Variations in sea surface temperatures, air temperatures, strength of upwelling, El Nino events, salinity, ocean currents, wind speed, and ocean productivity have all been shown to cause or reflect fluctuations in abundance and survival of salmonid populations. Oceanic conditions can vary on a seasonal, annual, decadal, or longer time scale but our ability to predict their impact on Columbia River steelhead stocks is very limited.

In general, the survival of steelhead from the smolt to adult stage is a reflection of interannual patterns of variation in ocean conditions. For example, smolt to adult survival rates for wild winter steelhead have been measured annually in Snow Creek, a small stream in Jefferson County, Washington. Measured smolt to adult survival rates ranged from 1.3% to 10.7% from 1978 to1994 (Randy Cooper, WDFW, personal communication). Of interest is a noticeable change in smolt to adult survival rates from the years 1978 to 1986 (range 2.2% to 10.7%; mean 6.3%), to the period 1987 to 1994 (range 1.3% to 6.6%; mean 2.6%). Wild steelhead marine survival has decreased to about half that of the late 1970s and early 1980s. Thus the period from the late 1980s to the present seems to represent a phase of low ocean productivity. This is likely a major factor contributing to the decline of wild steelhead populations (Cooper and Johnson 1992) in the LCSCI and elsewhere.

It is important to note that steelhead and other salmonids have evolved in a context of wide ranging oceanic environmental variability. The long term survival of wild steelhead stocks has depended on their development of compensating mechanisms (e.g., diversity of life histories, repeat spawning) that allow them to remain viable under such conditions. There is little that the LCSCI can offer to directly affect a positive response in ocean conditions. However, unchecked stresses posed by other risk factors that can be directly controlled (e.g., habitat, dams, hatcheries) will only lead to greater stock instability and risks to stock health when ocean productivity reaches inevitable low points in long term processes and cycles.

Hatcheries

<u>The use of hatchery strategies in the LCSCI area generally does not rectify the causes for decline of wild steelhead</u>. Hatchery strategies are instead used to provide harvest opportunities. Hatchery steelhead have been stocked into most rivers within the lower Columbia area. These plants began in the 1950s and grew to a high level in the 1960s when Skamania, Beaver Creek, and Cowlitz hatcheries reached full production. The Merwin Hatchery is a recently constructed mitigation facility located in the Lewis River basin. Planting levels have remained rather consistent from the late 1960s to the present. Annual steelhead plants into lower Columbia tributaries total approximately 2.3 million smolts. All hatchery steelhead released into this area are fin clipped. This permits anglers to harvest hatchery steelhead; all wild steelhead are to be released unharmed under Wild Steelhead Release regulations (see also Fisheries section).

Currently, two hatchery broodstocks are used extensively in western Washington - Skamania and Chambers Creek stocks, or their derivatives. Chambers Creek was the original source for most hatchery winter steelhead stocks in western Washington. It was the primary source for Beaver Creek winter steelhead, which in turn was the source of Skamania winter steelhead. Skamania is the only hatchery summer steelhead stock widely used by WDFW in western Washington. It was derived primarily from Washougal River broodstock, with a minor contribution also possible from the Klickitat River (Crawford 1979). Both winter and summer steelhead are cultured at the Cowlitz Hatchery. The winter-run hatchery stock originated from a mixture of fish from both native Cowlitz River and Chambers Creek fish, whereas the summer-run stock originated from Skamania adults. In 1993, a mitigation agreement in the Lewis River basin resulted in construction of the Merwin Hatchery. It produces summer and winter-run steelhead of Skamania and Beaver Creek Hatchery origin.

The genetic risks to wild steelhead imposed by interbreeding with hatchery steelhead are a key concern. Studies by WDFW have shown that when Skamania stock hatchery summer steelhead spawned naturally in the Kalama River, they were about 88% less effective at producing adult offspring compared to wild Kalama River summer steelhead (Leider et al. 1990). Initial results for similar studies in the Kalama River using Beaver Creek hatchery winter steelhead indicate similar differences in reproductive success (Hulett et al. 1996). Other investigations with steelhead suggest that hatchery/wild crosses may negatively affect the genetic diversity and long-term reproductive success of wild fish (Reisenbichler and McIntyre 1977; Phelps et al. 1994). In addition, researchers such as Byrne et al. (1992), Hulett and Leider (1993), and Reisenbichler and Brown (1995) suggest that hatchery programs based on wild broodstocks may also impose high genetic risks to wild stocks with whom the hatchery fish having more similar return and spawn timing, would increasingly interbreed. Although they may reduce genetic risks in some cases, hatchery steelhead stocks that spawn in the wild should not be assumed to be equitable substitutes for wild fish. These concerns have received increasing attention both generally (e.g, Waples et. al. 1990; Grant 1997; Reisenbichler 1997) and specifically regarding Columbia River salmonids (e.g., ISG 1996; NRC 1996; Bugert 1998). In the LCSCI area use of a late winter wild steelhead stock is being used to reintroduce steelhead in the upper Cowlitz River.

Carefully managed shifts toward alternative hatchery strategies may be appropriate for steelhead. However, due to a range of uncertainties as discussed above, alternatives must be very carefully designed to address risks and identify specific management objectives, especially given a range of stock abundance circumstances (low to high). This would include consideration of factors in the context of alternative supplementation or harvest augmentation objectives, including genetic concerns, local vs. distant stock source, rearing/release protocol, etc. Therefore, in the longer term, changes in hatchery strategies and broodstock management for Lower Columbia River steelhead may be appropriate, especially for the wild summer-run stocks which are at greatest risk. However, programmatic changes must be guided by the results of further analysis and agency/public review. In the meantime, key hatchery-oriented research opportunities will be identified for early implementation in the LCSCI that could contribute needed information about means to manage genetic risks, and/or the efficacy of hatchery strategies for stock rebuilding, while at the same time potentially benefiting natural production or harvest (see Chapter 12 - Monitoring and Evaluation). Such activities will be identified and implemented consistent with risk management guidelines in the WSP.

Regardless of the management goal or hatchery strategy under consideration now or in the future, risks of interbreeding between hatchery and wild steelhead must be managed so that gene flow is consistent with guidelines identified in the WSP. Strategies must be developed to reduce current levels of interbreeding between most hatchery and wild steelhead stocks. Thus, as part of the LCSCI, comprehensive hatchery steelhead stocking and management strategies will be developed to reflect the particular circumstances of each stock and/or basin.

Spawning times differ between hatchery and wild steelhead within and between summer and winter races, and this complicates assessment of risks to wild stocks due to their interbreeding with hatchery steelhead. Wild summer steelhead are more vulnerable to interbreeding with hatchery summer and hatchery winter steelhead because their spawning times are variable and overlap relatively closely by with the hatchery stocks. Since wild winter steelhead spawn later and their spawning time is the furthest removed from the hatchery stocks, interbreeding with hatchery steelhead is less likely. An exception exists when hatchery efforts utilize local wild broodstocks. In those cases, spawning times of hatchery and wild steelhead are expected to be similar. The Cowlitz Falls project is utilizing late Cowlitz winter-run stock to reintroduce steelhead to the upper Cowlitz River. In the target area, there is no risk of interbreeding with wild steelhead because no steelhead are present, although risks to wild resident fish populations must be acknowledged and addressed.

The traditional harvest augmentation goals of hatchery steelhead management and related hatchery practices have lead fishery managers to view current hatchery vs. wild run and spawn timing differences as opportunities to manage genetic risks to wild stocks while also providing harvest benefits. Obviously, for hatchery and wild steelhead to interbreed they must spawn in the same place at the same time. WDFW's current management approach to reduce interbreeding relies on three strategies: (1) maintain earlier spawn time of hatchery fish so most will be done spawning before the wild fish start, (2) if possible, acclimate and release hatchery steelhead smolts in lower river reaches where relatively few wild fish spawn and to which returning adult would be expected to home and hold to some extent prior to moving upriver for spawning, and (3) remove hatchery fish at high enough harvest and/or trapping rates so that no more than the targeted number are left at the time wild fish spawn.

These current strategies need to be complemented with additional appropriate actions to further reduce genetic risks of interbreeding between hatchery and wild steelhead (including unintended straying between watersheds). Various alternatives may exist. For example, although spawning time for hatchery stocks has been advanced considerably, additional artificial selection for this trait may further separate spawning times. However, the possible benefits of further selective breeding to reduce chances of hatchery/wild interbreeding may be offset by an increased likelihood that survival and genetic diversity within hatchery stocks would be reduced. Another possible strategy to explore involves sterilization of hatchery fish to prevent gene flow into wild populations. However, this option would need to be considered carefully, to understand the extent to which sterilized hatchery fish might mate with wild steelhead. If such mating would be expected, even greater risks to wild productivity and fitness would be expected, because the wild parent would produce no offspring. Although conceptually feasible, new strategies need to be fully reviewed and assessed with respect to their intended purpose and any unintended consequences.

Hatchery stocking programs pose risks to wild steelhead stocks associated with inter- and intra-specific ecological interactions. Releases of hatchery salmonids may competitively interact with coexisting wild stocks, and these interactions may have adverse consequences (IHOT 1994; McMichael et al. 1997). Recent WDFW research (e.g., McMichael et al. In press) has focused on the ecological risks of hatchery steelhead on wild steelhead populations, leading to several generalizations that may assist further development of conservation strategies to reduce the risks of ecological interactions. Examples of such generalizations are: (1) release only actively emigrating smolts (do not release non-migrant fish or those with a high probability of becoming residuals), (2) release fish at a size that is compatible with wild fish (e.g., not substantially larger than wild fish when the hatchery fish are released), (3) hatchery fish should not exhibit social behaviors that would adversely affect wild steelhead, and (4) release hatchery steelhead into areas either where there are no pre-existing wild steelhead, or where existing wild populations are abundant or healthy, and (5) where habitat diversity is complex, affording wild fish space to avoid stresses imposed by hatchery fish. These conditions would reduce both the likelihood of competitive interactions with hatchery smolts in direct contact with wild smolts, as well as the likelihood of indirect and latent effects of naturally produced offspring from hatchery parents competing in rearing streams with their pre-existing wild counterparts. A key short term operational measure will be implemented whereby non-migrant steelhead are not released into areas with pre-existing wild steelhead.

Interactions between releases of hatchery salmon and wild steelhead also likely occur. The magnitude and effect of these interactions merits additional review; however, it is expected that many of the generalizations listed above for hatchery steelhead will also apply to hatchery salmon (e.g., hatchery coho) interacting with wild steelhead. Other considerations include the potential for predation of salmon species on wild steelhead, and inversely, predation by hatchery steelhead on salmon species of concern (e.g., chum fry). These issues will best be addressed via systematic review and completion of focused risk assessments.

Fisheries

There is no legal harvest of adult wild steelhead in sport fisheries in the LCSCI area. Regulation of current harvest practices in the LCSCI area is designed to protect wild juvenile and adult steelhead, but some unintentional mortality may occur. Juvenile steelhead are protected using several approaches. Retention of trout caught from streams is only allowed if they are over 8 inches long. In general, most tributaries are closed to fishing from November to June. Streams are closed to fishing to protect outmigrating steelhead smolts from March 15 to May 31. In larger rivers, regulations further protect smolts outmigrating in the spring by increasing minimum size limits to 12-14 inches. Since the mid-1980s legal harvest of wild adult steelhead in parts of the LCSCI area has been eliminated by applying Wild Steelhead Release regulations. These regulations allow the retention of only unmarked steelhead (hatchery origin); unmarked (wild) steelhead must be released. These regulations are now implemented for steelhead throughout the LCSCI area.

Despite these protective regulations, wild steelhead mortalities may occur in several ways. First, undersized juvenile steelhead and unmarked adult steelhead that are legally caught and released may not survive after release. The extent of hooking and release mortality for juvenile steelhead is unknown. In general, for adults, available information suggests hooking and release mortality less than about 10%. Available information suggests it may be up to 40% when bait is used.

No sport harvest fisheries targeting juvenile or adult wild steelhead now occur in the LCSCI area, but incidental catches of wild steelhead may occur in tributary and mainstem fisheries. The extent to which juvenile steelhead are caught in trout fisheries is unknown. Cramer (1997) estimated that mortality of juvenile steelhead in trout fisheries in popular Washington streams has declined from 15-20% up to the early 1980s to 5-10% in 1986 and thereafter. However, if substantial numbers of juvenile steelhead are retained or caught and released, impacts could be considerable.

Incidental catches of adult wild steelhead also occur in maintstem sport and commercial fisheries for other species. In addition, tribal fisheries in the mainstem harvest adult wild steelhead. Identifying and resolving related conservation needs is being addressed by the fishery co-managers (and NMFS) that are party to the Columbia River Fish Management Plan under the US vs Oregon agreement. That Plan is now being re-negotiated and identifying and responding to conservation needs will be an integral parts of that process. The LCSCI will defer to that process to guide management of impacts on wild steelhead in affected fisheries.

In general, selective harvest of hatchery steelhead (e.g., through retention of only fin marked fish) can be used to reduce genetic risks to wild stocks by lowering the number of hatchery fish that would otherwise be available to interbreed with wild steelhead. Regulation changes that would increase the harvest of hatchery steelhead would further decrease the escapement of hatchery steelhead. This may be especially practical for winter steelhead because differences in run timing would allow focused target fisheries with relatively low impact on wild stocks. Since the run timing of adult hatchery and wild summer steelhead is nearly identical, higher harvest rates on hatchery summer steelhead may also cause increased handling and risk of hooking mortality for wild fish. Longer term opportunities to increase harvest of hatchery steelhead may include improving access to fish by adjusting harvest times and areas in conjunction with managed homing of hatchery fish to those areas. Even at current harvest levels every effort needs to be taken to reduce the unintentional mortality of legally hooked and released wild steelhead. This might include restrictions on gear types or on fishing in locations or at times when high hooking mortality is suspected to occur (e.g., on holding areas or during periods of excessively high summer water temperature).

<u>Steelhead are not targeted in commercial or sport fisheries that occur in the ocean</u>. However, steelhead can be incidentally harvested in ocean fisheries targeting other species. Cooper and Johnson (1992) and NMFS (1996b) described available information on steelhead mortalities attributable to ocean fisheries, including high seas driftnets. Such fisheries may have had a substantial impact on declines in wild steelhead along the Pacific Coast of North America in the past. However, driftnet fisheries have been largely curtailed. For example Japan, a major driftnet operator, ceased such activities in 1992. In general, the percentage of steelhead caught in ocean fisheries is thought to be low (Cooper and Johnson 1992).

Predation

Fish, birds, and marine mammals have evolved to coexist in fully functioning ecosystems and utilize wild salmonids, including steelhead, as food sources. However, humans have altered the environment by introducing non-indigenous fish species, constructing hydroelectric dams, and making other alterations to salmonid habitat. Such alterations can create circumstances where occurrence and magnitude of predatory impacts to wild salmonids are increased. The occurrence and magnitude of predation by other fish, birds, and mammals specifically on wild steelhead is difficult to assess and has not been quantified. The discussion below summarizes information about risks to wild steelhead posed by predation.

Fish

Non-indigenous predatory fishes such as walleye, smallmouth bass, and channel catfish, and native species such as northern squawfish have been found to consume significant numbers of juvenile salmonids. Northern squawfish are native to the Columbia River basin while walleye, smallmouth bass, and channel catfish are non-native species that were introduced earlier this century (Wydoski and Whitney 1979). Rieman et al. (1991) found that these predators consume between 9% an 19% of the juvenile salmonids entering Columbia and Snake River Reservoirs, with northern squawfish accounting for 78% of this loss. The estimated mortality from predation of juvenile steelhead in John Day Reservoir from 1983 to 1986 averaged 12% (Rieman et al. 1991). Based on data from a series of Columbia River index sites, predation on salmonids in the area below Bonneville Dam received the highest salmonid predation index rating; it was greater than five times predation index rating for the John Day Reservoir (Ward et al. 1995). This suggests that predation on steelhead by other fishes in the lower Columbia River is likely to have exceeded 12%.

The Bonneville Power Administration has funded a major program to reduce the northern squawfish population and its impacts on anadromous salmonids. Between 1990 and 1996, 1.1 million northern squawfish greater than 250 mm long have been removed from the Columbia River (Friesen and Ward In press). The reduction of squawfish below Bonneville Dam has reduced the predation index by 48% (Zimmerman and Ward In press). The reduction in the number of squawfish and the associated predation index has likely decreased predation on salmonids below Bonneville Dam. However, as stated above the predation rate on wild steelhead juveniles remains undefined.

Releases of certain species of hatchery salmonids may pose predation risks to wild steelhead juveniles. For example, sea-run cutthroat trout are thought to have piscivorus tendencies and may consume wild steelhead juveniles in some circumstances. Some salmon species are known to have innate aggressive tendencies (e.g., juvenile coho salmon) and may pose a predation risk to wild steelhead fry. In most cases, the risks from predation would be greatest when the size of the predators is considerably larger than the sizes of the prey. Hatchery smolts do not present significant predation risk when are actively outmigrating to the ocean. However, some released hatchery fish intended to smoltify and outmigrate may fail to do so and instead remain in streams (residualize) for extended periods before emigrating or dying. Such hatchery fish may pose considerable predation risks to wild steelhead fry and parr.

Birds

Gulls, mergansers, great blue herons, terns, alcids, and cormorants are known to have highly predatory habits that can impact juvenile steelhead. Information is beginning to become available on the extent of bird predation on salmonids. Based on population sizes and feeding habits terns, cormorants, and mergansers are likely to be the most effective predators on juvenile steelhead in the Columbia River basin. Staff of the Columbia River Inter-Tribal Fish Commission are studying the bird predation in the Columbia River basin from the mouth to Tri-Cities. Preliminary results indicate that the Caspian tern population has increased from 1,300 breeding pairs in 1987 to approximately 9,000 pairs in 1997. This work also found that an estimated 6.9% of the steelhead outmigrants receiving PIT tags in 1997 were consumed by terns, based on expanded tag recoveries. Increases in bird populations in the LCSCI area may be related to associated increases in bird habitat afforded by new islands created by accumulated deposits of material resulting from channel dredging activities.

The abundance of cormorants and other predatory birds has increased substantially in recent years. Emmett (1997) indicated that cormorant populations have increased up to 15-fold in some areas along the West Coast. In 1997, cormorant predation on rainbow trout in some lower Columbia River lakes was a significant problem (WDFW data). Wood (1987) estimated that mergansers consumed from 24% to 65% of the coho salmon production in a British Columbia coastal stream.

Marine Mammals

Various efforts have explored marine mammal predation on salmonids in the Columbia River, but quantifiable data on consumption rates are scarce (NMFS 1997). Pinnipeds such as California sea lions and harbor seals are both present in the lower Columbia River. Sea lions are found in the Columbia River from September through May and have been observed at Bonneville Dam (Huber et al. 1996). Harbor seals are present through the entire year below the mouth of the Cowlitz River (Huber et al. 1996). Between 1977 and 1992 the harbor seal population has increased at an annual rate of 7% in Washington and Oregon to an estimated 28,500 (Barlow et al.1995). Counts of California sea lions in Oregon have increased from 1,000 to 2,000 in the late 1970s to 5,000 to 7,000 in the early 1990s (Barlow et al. 1995).

Pfeifer (1987) estimated that 43% of the adult steelhead run into Lake Washington in 1986-87 was lost to marine mammal predation, where a major fish passage problem occurs at the Ballard Locks. Roeffe and Matte (1984) found that pinniped predation on the Rogue River adult summer steelhead population was 1%. Recent information by Fryer (In press) found abrasions caused by marine mammals at Bonneville Dam has increased from 2.8% in 1991 to 25.9% in 1996 for adult sockeye salmon and from 10.5% in 1991 to 31.8% in 1994 for adult spring-summer chinook. Based on the severity of the abrasions, it was estimated that 3% of these adult salmonids passing Bonneville Dam would not survive to spawn (Fryer In press). Byrne (1995), working with adult winter steelhead in the LCSCI area, found that marine mammal abrasions on hatchery winter steelhead returning to the Elochoman River increased from 13% in 1984 to 32% in 1994. Although these data are compelling and point to increasing risks to wild steelhead due to marine mammal predation, a general lack of data makes it impossible to accurately determine the magnitude and focus of the problem.